ON LOCAL RAIN FADE MODELING AND PREDICTION FOR MM-WAVE SATCOM SYSTEM ENGINEERING

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Outline

Satcom systems engineering (brief history)

Potential Improvements

- Refined statistics
- Improved event prediction methods

Example: Event prediction via radiometric data

Open Issues (?)

Satcom Systems Engineering

First generation –

- Link budget analysis
- Rain attenuation statistics
  - Fade margin
  - Outage probability analysis

Second generation –

- Power control and coding
- Dynamic capacity allocation (trunking effect)
- Site diversity

Potential Improvements

Must maximize network operating efficiency

Resources must be used to combat rain fades – combinations of 2nd generation methods

Approaches:

- Refined statistics for optimum efficiency
  - Maximize efficiency by using multiple data classes (priorities)
  - Implies multi-tiered service/cost structure
  - Challenge: deep fades
- Improved prediction methods for adaptivity

Improved Prediction Methods

(e.g., nowcasting)

Adaptive approaches — desired properties:

- Successful in anomalous phenomena (can always have a bad day)
- Responsive to fine structure (short-term fade statistics)
- Site-nonspecific (robust)
- Can use information correlated in space and time, e.g.:
  - IR/visual satellite data
  - Radar data
  - Radiometric data

Attenuation Prediction via Radiometric Data

Approach: Analysis of correlation between fluctuations in sky temperature and attenuation caused by rain

Data reduction/processing software:

- C program for generation of "clean" data from PV1 files:
  - data/status unpacking
  - detection of missing data
  - flexible processing of status data
  - calibration processing
- MATLAB for statistical data processing
- MATLAB/Excel for plotting

Attenuation Prediction via Radiometric Data (cont'd)

Goal: Investigate usefulness of on-site radiometer sky temp measurements for prediction of link attenuation due to rain

Example: Time difference of level crossing — *a posteriori* event detection analysis (preliminary)

For rain event k, TDLC is

$\Delta^{(k)}(l_b, l_r) = t_b^{(k)}(l_b) - t_r^{(k)}(l_r)$

where

$t_b^{(k)}(l_b)$ = time beacon attenuation crosses l_b dB

$t_r^{(k)}(l_r)$ = time ARD crosses l_r dB

Preliminary Results

Data set: 13 days in 1994 (16 events)

Parameters:

- Rain event designated if both beacon atten. and ARD > 7 dB
- Beacon data filtered using 9-point median filter

TDLC computed for *known* events => includes times only for correctly detected rain events.

Sample mean:

$\bar{\Delta}(l_b, l_r) = \frac{1}{N} \sum_{k=1}^{N} \Delta^{(k)}(l_b, l_r)$

$\bar{\Delta}(5, 5) = 7.2$ sec

Summary

Complete solutions will require integration of techniques

Fading unavoidable => Mapping of outage statistics to service structure

Deep fading => Prediction using temporally/spatially correlated data

—> What is Needed?